Amendments to the Specification:

Please replace the title of the application with the following title:

~~FUSER~~ ~~SYSTEM~~ FUSING APPARATUS AND METHOD FOR LIQUID TONER ELECTROPHOTOGRAPHY USING MULTIPLE ~~ROLLERS~~ STATIONS HAVING DIFFERENT PREFUSING AND FUSING TEMPERATURES

Please replace the paragraph starting at page 1, line 8, with the following paragraph:

The present invention relates to fusing devices and systems for use with electrophotographic processes and particularly relates to the use of such devices and systems with liquid toner materials.

Please replace the paragraph starting at page 1, line 13, with the following paragraph:

Electrophotography forms the technical basis for various well-known imaging processes, including photocopying and some forms of laser printing. One basic electrophotographic process involves placing a uniform electrostatic charge on a photoreceptor, and then exposing the photoreceptor to activating electromagnetic radiation in particular areas that correspond to an image to be printed or transferred. The electromagnetic radiation, which may also be referred to as "light", may include infrared radiation, visible light, and ultraviolet radiation, for example. This exposure of the photoreceptor to light dissipates the charge in the exposed areas to form an electrostatic latent image. The resulting electrostatic latent image is developed with a toner, and then the toner image is transferred from the photoreceptor to a final substrate, such as paper, either by direct transfer or via an intermediate transfer material. The direct or intermediate transfer of an image typically occurs by one of the following two methods: elastomeric assist (also referred to herein as "adhesive transfer") or electrostatic assist (also referred to herein as "electrostatic transfer"). Elastomeric assist or adhesive transfer refers generally to a process in which the transfer of an image is primarily caused by surface tension phenomena between a photoreceptor surface and a temporary carrier surface or medium for the toner. The effectiveness of such

elastomeric assist or adhesive transfer is controlled by several variables including surface energy, temperature, pressure, and toner rheology. Electrostatic assist or electrostatic transfer refers generally to a process in which transfer of an image is primarily affected by electrostatic charges or charge differential phenomena between the photoreceptor surface and the temporary carrier surface or medium for the toner. Electrostatic transfer, like adhesive transfer, is controlled by surface energy, temperature, and pressure, but the primary driving forces causing the toner image to be transferred to the final substrate are electrostatic forces. After the toned image is transferred by either type of transfer method, electrophotographic processes may further include the processes of fusing the transferred image to the substrate, cleaning the photoreceptor, and erasing any residual charge on the photoreceptor to prepare the system for the transfer of a new image.

Please replace the paragraph starting at page 5, line 18, with the following paragraph:

The fusing apparatus may be included within an electrophotographic printing device, wherein the first nip area between the prefusing roller and backup roller is positioned within the printing device to contact an image on a substrate prior to the second nip area between the fusing roller and backup roller contacting the image on the substrate. At least one of the prefusing roller and the backup roller may be maintained at a temperature between about 100°C and about 150°C, and at least one of the ~~first and~~ fusing roller and the backup roller may be maintained at a temperature between about 130°C and 220°C.

Please replace the paragraph starting at page 7, line 11, with the following paragraph:

Referring now to the Figures, wherein the components are labeled with like numerals throughout the several Figures, and initially to Figure 1, a schematic view of one typical fuser apparatus 100 used in dry toner applications is illustrated, which generally includes a first roller 102, a second roller 106, and a substrate 114 moving in a direction generally shown by the arrow 103. The first roller 102 can be heated

internally, such as by a heating element 104, which may be a halogen lamp, for example, although other heating elements may be used, including heating blankets and heating lamps. The <u>second roller or</u> backup roller 106 is positioned to be in contact with the first roller 102, thereby creating a contact nip <u>(nip area)</u> 116 between the rollers 102 and 106 that is sufficiently loose to accommodate the thickness of substrate 114. In many cases, the backup roller 106 is also heated by a heating element 108 similar to that used with the first roller 102. At least one of the rollers is typically driven by a driving mechanism (not shown), and the rollers 102, 106 rotate as generally shown by arrows 110, 112, respectively. Substrate 114 with non-fused or toned images on one side is typically provided to the nip area 116 and conveyed through this nip area 116 in the direction 103 so that the combined heat from the rollers 102, 106 melts the toner, fusing it onto the substrate 114. The image (not shown) can face either of the rollers 102, 106 if both are heated, but typically faces the heated roller if only one of the rollers is heated.

Please replace the paragraph starting at page 8, line 15 with the following paragraph:

More specifically, the prefusing roller 12 is arranged relative to the backup roller 16 to evaporate at least an initial portion of a carrier liquid from a liquid toned image on the substrate 24. The rollers 12 and 16 are preferably positioned relative to each other in such a way to provide a nip area 32 between them. This nip area 32 is the area or region where the two rollers 12 and 16 are in contact with each other, which determines the length of time during which a moving substrate will contact the heated prefusing roller <u>12</u> as it passes through the nip area <u>32</u> (i.e. "dwell time"). Because the rollers 12 and 16 are preferably in contact across the entire lengths of both rollers, the size of the nip area <u>32</u> is mainly controlled by adjusting the width of the contact area in the travel direction of the substrate <u>24</u>. The size of the nip area 32 may be controlled, for example, by adjusting the hardness of one or more of the roller layers of either or both of the rollers, and/or by increasing or decreasing the force or pressure that is pressing the rollers 12 and 16 toward each other. For example, the size of the nip area 32 can be decreased by increasing the hardness or durometer of at least one of the rollers 12 and 16, and/or decreasing the

pressure applied to the two rollers. These parameters and adjustments should preferably be chosen to accommodate the thickness and various other material properties of any substrates that will pass through the nip area 32. For one example, although a relatively thin material may be able to pass through a relatively tight or high-pressure nip area, it is also important that the rollers are not pressed so hard toward each other that the substrate will tend to wrinkle or tear when passing through the nip area. In one preferred embodiment of the present invention, the nip width is in the range of 0.5 mm to 3 mm, with a more preferred range being 1.5 mm to 2.5 mm.

Please replace the paragraph starting at page 9, line 7, with the following paragraph:

As described above, the amount of time the substrate 24 can spend in the nip area 32 may be at least partially controlled through selection of the durometer or hardness of the outer coating or rubber layers of the rollers 12 and 16, or the hardness of the rollers themselves if no coating layers are provided. The hardness of the coating layers (e.g., rubber layers with or without any overcoat or release layers) is important because if the roller is too soft, the coating may bend, which may cause cracking or delamination of the coating. In addition, the substrate to which the toner is being fused might also bend and distort if the hardness of the rollers is too low. If the rollers are relatively hard, the nip area 32 will be relatively small and the duration of time that heat may be applied to the toner and substrate will be reduced, which may result in insufficient fixation of the toner to the substrate and/or insufficient evaporation of solvent. Furthermore, ~~a nip~~ the nip area 32 that is provided between rollers that are too soft and/or have too wide of a nip area may tend to cause the final substrate to wrinkle and may trap evaporated solvent between the rollers 12 and 16. In contrast, a nip area 32 that is provided between rollers that are too hard and/or have too narrow of a nip area may not provide enough dwell time between the rollers and the image to evaporate a sufficient amount of the solvent.

Please replace the paragraph starting at page 10, line 7, with the following paragraph:

The rollers 12 and 16 may be made by a wide variety of manufacturers, including rollers commercially available from Bando USA Inc. (Itasca, Illinois), Bando International (Chuo-Ku, Kobe, Japan), Minco Manufacturing (Colorado Springs, CO), and Ames Rubber Co. (Hamburg, N.J.). Several important characteristics that are preferably considered in the selection of rubbers used on fusing rollers include: the durability at a particular temperature, including scratch and solvent resistance for liquid electrophotography; the compliance for optimal nip residence time; and, in many cases, the ability to act as an adherent substrate for any sort of a release or low surface energy layer which may be applied. Examples of rubbers and compositions, along with parameters that may be considered in the selection thereof, are described, for example, in U.S. Patent Nos. 5,974,295 (De Neil, et al.) and 6,602,368 (Geiger). Coatings can be included on at least one of the fuser rollers such as rollers 12 and 16 to allow the toner particles to release easily from the surface, even after heating of the toner particles. Fluoroelastomers and polydimethyl siloxanes are two examples of coatings that may be used for such applications because of their low surface energies. For example, dimethyl siloxane tends to rapidly increase in surface energy at higher temperatures, which can thereby cause offset, and is therefore more effective at lower temperatures, as ~~in the first fusing station~~ <u>for the prefusing roller</u> 12. For another example, a fluorinated polymer such as Teflon® can be used without causing offset in fusing stations where the rollers are at a relatively high temperature and where the image to be fused is substantially dry, such as on the second or final fusing roller, as will be described in further detail below.

Please replace the paragraph starting at page 11, line 29, with the following paragraph:

As described above, the arrow 26 of Figure 2 shows the direction the substrate 24 is moving in this embodiment. To facilitate such movement of the substrate 24, the rollers 12 and 16 rotate in the directions shown by arrows 34 and 40, respectively. One

or both of these rollers 12, 16 may be driven by a driving mechanism (not shown) of any type capable of providing the desired movement of the substrate 24 through the system 10. A liquid toned image may be provided on at least one of an upper surface 20 and a lower surface 22 of substrate 24 when that substrate 24 is fed into the nip area 32. The roller that faces the image or images, whether it is roller 12, roller 16, or both rollers 12 and 16 if the image is printed on both sides of the substrate 24, should be heated to provide a temperature in the nip area 32 that will preferably allow at least a portion of the carrier liquid to evaporate and will more preferably cause a substantial portion of the liquid to evaporate.

Please replace the paragraph starting at page 12, line 10, with the following paragraph:

When a toned image is provided on a single surface of the substrate 24, it is preferred that the toned image faces upwardly or substantially upwardly, because the carrier liquid will typically rise and move away from the substrate 24 as it evaporates. For example, in this preferred embodiment, the image would preferably face roller 12. If the toned image is facing downwardly (in this case, toward the roller 16), the rising evaporated carrier may be at least partially reabsorbed into the substrate 24 or image or trapped underneath the substrate 24, where it might condense. However, a substrate provided with a toned image facing down (e.g., toward the roller 16) is considered to be within the scope of the present invention, although the amount of toner evaporation may differ from those situations where the image is facing upwardly. In these situations, the size of the nip area and the temperature of the rollers may need to be adjusted accordingly. Thus, if the toned image is facing down in a system such as that shown in Figure 2, various parameters of the system (e.g., temperature, pressure~~, etc.~~) may be adjusted to different levels than when the toned image is facing up in the system in order to achieve the same amount of carrier liquid evaporation.

Please replace the paragraph starting at page 12, line 25, with the following paragraph:

In order to heat the rollers 12 and/or 16 to a desired temperature, a variety of heating methods and devices may be used. One example of a heating element that can be used to heat the various ~~rolls~~ rollers of the present invention is a quartz halogen lamp, although other known means may be used to keep the rollers evenly heated. Halogen lamps provide certain advantages because they heat quickly and evenly, become very hot, and have a relatively long life. They can also be situated within a hollow core of a roller without requiring contact with the roller itself, which is a feature that may help reduce the chance of mechanical failure associated with a loss of contact. In the embodiment of Figure 2, for example, rollers 12 and 16 are provided with internal heating elements 4 and 36, respectively, which may be halogen lamps or other heat sources. When such internal heating sources are used, the rollers 12 and 16 may include metal cores coated with heat-resistant rubber and a very low surface energy coating, such as silicone.

Please replace the paragraph starting at page 13, line 7, with the following paragraph:

Another parameter that can be adjusted and controlled to achieve a certain amount of liquid carrier evaporation is the temperature of the rollers 12 and 16. In a preferred embodiment, roller 12 is heated to a temperature needed to evaporate the carrier. In such an embodiment, roller 16 may be heated to the same temperature as the roller 12 or to a lower temperature than the roller 12, or roller 16 may not have its own source of heating. It is the primary function of roller 12 in this embodiment to evaporate carrier liquid from a toned image on a substrate. It is a primary function of roller 16 to provide a rigid backup support for the substrate 24 as it is being prefused, and subsequently, fused. However, either one or both of these rollers 12 and 16 can be heated as necessary to provide a relatively constant amount of heat to the substrate 24. In situations where only a small amount of heat needs to be transferred to the substrate 24 for carrier liquid evaporation, for example, only one of the rollers 12, 16 may need to be heated, or it may be possible for both rollers 12, 16 to be heated to a relatively low temperature to achieve the same level of evaporation. Because the process of evaporation may tend to cool one

or both of the rollers 12, 16 during the pre-fusing or evaporation step, one or both of the rollers 12, 16 may be provided with a feedback system to regularly monitor and adjust the amount of heat provided by the heat source or sources to maintain the temperature of the rollers 12, 16 within a desired range. Although the preferable temperature of the prefusing roller(s) is determined primarily by the liquid toner characteristics, the vaporization point of the chosen carrier liquid, and the fuser roller coating parameters, one preferred temperature range for the rollers 12 and/or 16 is between about 100°C and 150°C, with a more preferable temperature range of the rollers being maintained between about 110°C and 130°C.

Please replace the paragraph starting at page 13, line 29, with the following paragraph:

The fusing apparatus or system 10 of Figure 2 further includes a fixation or fusing step accomplished in a second fusing area with the roller 14 positioned to form a nip area 42 with roller 16. The fixation or fusing roller 14, in combination with roller 16, is placed to contact substrate 24 at some point after heat from the ~~first nip~~ nip area 32 has heated the substrate 24 and caused at least a portion of the carrier liquid to evaporate. Again, the arrow 26 shows the direction of movement of the substrate 24, which also shows the direction the substrate 24 moves toward the fusing roller 14 and nip area 42. The spacing or gap between the roller 12 and the roller 14 is preferably as small as possible to help to minimize the amount of fusing space required in the printing unit. However, it may also be desirable to provide at least a certain predetermined distance between the rollers 12 and 14, such as to keep the heat from one roller from affecting the heat provided by the other roller.

Please replace the paragraph starting at page 14, line 10, with the following paragraph:

Once the substrate 24 has at least partially passed through the nip area 32, it is conveyed to move forward, then pass into the fusing or fixation nip (nip area) 42 between the rollers 14 and 16. To facilitate such movement of the substrate 24, the rollers 14 and 16 rotate in the directions shown by arrows 38 and 40, respectively. The roller 14 within

a particular system 10 may be the same or different from the rollers 12, 16 used in the prefusing step, in durometer, rubber/coating thicknesses, and/or other parameters. Because the various toned images and the substrates on which they are to be fused can vary widely, the features and positioning of the rollers 14, 16 can also include many different characteristics and spacings relative to each other in the same way that the rollers 12, 16 can include a wide variety of characteristics and spacings relative to each other. Thus, the various alternatives and considerations described above relative to the rollers 12, 16 are applicable to the relationship between rollers 14, 16. However, because the roller 16 is common to more than one heating or fusing step (i.e., the roller 16 is part of both nip area 32 and nip area 42), consideration of the desired temperatures, pressures, and other parameters of both nip areas 32, 42 should be considered. For example, the temperature of the roller 16 should not be too high to achieve desired temperature characteristics in the first nip area 32, but should also not be too low to achieve desired temperature characteristics in the second nip area 42.

Please replace the paragraph starting at page 14, line 28, with the following paragraph:

The roller pair 14, 16 preferably heat the toner particles to a temperature above their glass transition temperature (T_g) relatively quickly to provide the desired final fusion of toner particles to the substrate 24. Because the T_g of liquid toners will vary, the temperature needed to reach this point will also vary, respectively. Thus, nip area 42 at the second fusing step is usually maintained at a higher temperature than the nip area 32, which is mainly designed to provide carrier liquid evaporation so that the substrate 24 reaches the fusing step with a relatively dry toned image (i.e., relatively free of solvent). In order to maintain these relatively high temperatures, it is therefore preferable that both of the rollers 14, 16 are provided with a heat source, although it is possible that only one of the rollers has its own heat source. In the embodiment of Figure 2, for example, rollers 14 and 16 are provided with internal heating elements 44 and 36, respectively, which may be halogen lamps or other heat sources, such as are described above for the heat sources 4 and 36.

Please replace the paragraph starting at page 15, line 10, with the following paragraph:

One preferred range of fusing temperatures for the nip area 42 between the rollers 14, 16 is between 130°C and 220°C; however, some liquid toners are more preferably fused at a temperature above 150°C. The fusing temperature is preferably not so high that it causes "offset" or transfer of the image to either of the fusing rollers. The fusing roller 14 may therefore be manufactured with the same core and material layers as the rollers 12 and 16 (discussed above); however, a release layer can be included on the fixation roller 14 that has a relatively high surface energy, where such release layer may be provided in the form of a molded sleeve formed from a fluorinated polymer, for example. Thus, because the image has been partially fused and a considerable portion of the carrier liquid will have been evaporated by the time the substrate 24 reaches the nip area 42, the fusing roller 14 may include materials that can withstand higher temperatures than the materials used on the prefusing roller 12, such as sleeves or coatings available under the trade name "Teflon". In one exemplary embodiment of the present invention, the thickness of a coating layer on the fixation ~~rollers~~ roller 14 can be about 0.025 mm to 0.050 mm, and the total diameter of the roller can be about 35 mm with a Shore A hardness between 10 and 30. Further with regard to this exemplary embodiment, the rollers 14 and 16 preferably have a pressure applied between them of between 10 pounds (4.5 kg) and 60 pounds (27.2 kg) to create ~~a nip~~ the nip area 42 in a range of 1 mm to 3 mm, and more preferably is maintained in a range between 20 pounds (9.1 kg) and 45 pounds (20.4 kg) of pressure. As with the rollers in the prefusing step, the pressure may also be defined as approximately 2.2 to 5.0 pounds per lineal inch.

Please replace the paragraph starting at page 16, line 1, with the following paragraph:

In one preferred embodiment of the present invention, the backup or compression roller 16 has a Shore A hardness of about 10. The backup roller 16 is supplied with an internal heating element 36 that is maintained at approximately the same temperature as the temperature of the prefusing roller 12. The prefusing roller 12 has a Shore A hardness of about 20-30 and is coated with a polydimethyl siloxane as a low surface

energy release coating that is also absorptive, which provides enhanced lubricity and release characteristics. The two rollers 12, 16 are held together at a total force of about 45 pounds (20.4 kg) of pressure at nip area 32, which is preferably maintained at a temperature of about 100°C to 150°C. The fixation roller 14 is also configured to contact backup roller 16 with about 45 pounds (20.4 kg) of force at nip area 42. Roller 14 is covered with a release sleeve made from a fluorinated polymer that is able to withstand higher temperatures in the range of about 130°C-220°C. The nip area 42 is thus preferably maintained at a higher temperature than roller 16 due to the higher temperature supplied by roller 14.

Please replace the paragraph starting at page 16, line 14, with the following paragraph:

In one preferred embodiment of the present invention, the diameter of all of the rollers 12, 14, and 16 is approximately 35 mm, but this size is primarily chosen to accommodate the size of the electrophotographic apparatus. The rollers may be the same or different sizes than each other. A lower limit on roller diameter may be constrained at least by the need for rigidity of the rollers and sometimes by the need for a hollow space inside in which to insert heating elements while maintaining sufficient structural strength for the rollers. A lower limit on the diameter of roller 16 may also be constrained by the need to have two ~~nips~~ nip areas 32, 42 that are spaced relatively near to each other.

Please replace the paragraph starting at page 16, line 22, with the following paragraph:

Because the substrate 24 passes through two ~~nips~~ nip areas 32, 42 sequentially, it is preferable to maintain a constant velocity of the rollers 12, 14, 16 to prevent wrinkling, tearing, or other damage to the substrate 24. There are several ways to drive the rollers, such as by driving the cores of the rollers 12, 14, and/or 16 with gears or attached motors. Another way is shown in the embodiment of Figure 3, as apparatus 200, which shows the addition of drive rollers 207, 209, and 211 to the embodiment of Figure 2, with a substrate 203 moving in a direction 205 through a prefusing nip formed by rollers 213 and 217, and then a fusing nip formed by rollers 215 and 217. In particular, drive roller

211 contacts the surface of roller 217 to rotate this roller 217 in a direction that is opposite that of the drive roller 211 (as shown by arrows 219, 225). Further, the drive roller 207 similarly contacts the surface of roller 213 to rotate this roller 213 in a direction that is opposite the rotation of drive roller 207 (as shown by arrows 223, 227). Still further, the drive roller 209 similarly contacts the surface of roller 215 to rotate this roller 215 in a direction that is opposite the rotation of drive roller 209 (as shown by arrows 221, 229) In this embodiment, drive rollers 207, 209, and 211 can be engaged by either individual motors or drive systems, or can be driven by the same motor or drive system (not shown).

Please replace the paragraph starting at page 17, line 8, with the following paragraph:

In addition, Figure 3 illustrates an additional optional feature of a system of the present invention that is particularly designed to help maintain the flatness of the ~~substrate 24~~ substrate 203 as it moves between the two nips. In particular, one or more guides, such as the one shown schematically as guide 201, may be provided to keep the substrate 203 from curling or bending after being exposed to heat in the prefusing step. The guide 201 may take any number of forms that do not damage the toned image or interfere with the movement of the substrate 203, but prevent or minimize folding or mutilation of the substrate 203 as it enters the nip area. While these guides 201 are illustrated in the embodiment of Figure 3, such guides may be used in any other embodiments of the present invention, such as the embodiment shown in Figure 2.

Please replace the paragraph starting at page 17, line 18, with the following paragraph:

It is important that a fuser unit containing systems of the type shown in Figures 2 and 3 maintain adequate airflow to allow evaporated solvent and excess heat to escape. Evaporated solvent that is trapped in the fuser unit can re-condense or become re-absorbed into the final substrate or image, thereby destroying image quality. For this reason, the apparatus should preferably have an adequately open construction that allows solvent to escape. Additionally, a fan or other air movement device, such as cooling

element 50 shown in Figure 2, can be positioned to draw evaporated solvent from the area and/or to cool at least one of the rollers or the substrate, such as to help maintain the rollers and substrate within a preferred temperature range.